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Abstract

Identifying Buyer Market Areas and the Impact of Buyer Concentration in Feeder Cattle Markets Using Mapping and Spatial Statistics

The size and shape of market areas for buyers from four major cattle feeding areas (Dodge City, Amarillo, Omaha, and Greeley) are determined by mapping data from the nation's largest video auction. Spatial statistics are also examined to determine their ability to identify market areas for feeder cattle. Mapping shows that procurement areas for feeder cattle buyers are large, irregularly shaped, and overlap substantially. Currently available spatial statistics were not found to be helpful in defining market areas so a new statistic (BT_{ik}) was developed to determine primary market areas. Feeder cattle buyers behave as oligopsonists in counties where most buyers are from one feeding area and prices are higher for feeder cattle in counties where two or more market areas overlap.

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Introduction

Defining relevant market areas is critical in testing for market power, yet describing market areas is difficult. The large and rapid consolidation of the beefpacking industry during the past 15 years has motivated considerable research assessing market power in cattle markets (e.g., Schroeter; Menkhaus, St. Clair, and Ahmaddaud; Ward; Marion, Geithman, and Quail).[1] However, major structural changes have occurred at other points in the beef marketing channel. For example, the number and size of feedlots that are close to large packing facilities are growing.[2] Contracts between packers and feedlots are also more common now than 10 years ago (Ward; Schroeder et al.). These structural changes (number, size, location of firms, and growth in contractual arrangements) suggest feeder cattle buyers may be able to pay different prices for cattle depending on the cattle's location and the level of competition they face at each location (spatial price discrimination) (Greenhut and Benson).

The objectives of this study are to 1) define major market areas for feeder cattle buyers, 2) develop a statistical test using spatial statistics to determine feeder cattle buyer market areas, and 3) determine the effect on feeder cattle prices resulting when locations are either dominated by buyers from only one market area or are located where market areas overlap.

A test of monopsonistic buyer behavior in feeder cattle markets must include a clear delineation of market areas. Buyers in spatially separated markets probably compete directly with each other only within a given procurement area and may pay different prices for cattle within their service (market) area than in locations located in more than one market area (Benson and Faminow; Bailey and Peterson).

Since secondary data identifying relevant feeder cattle market areas are not publicly available, primary data provided by the nation's largest cattle video auction are used to determine market areas. Cattle sold at the video auction come from most major feeder cattle production areas. Buyers from all major cattle feeding locations participate, making it possible to study the size and shape of several different market areas.

While not all cattle sold through the video auction are shipped to feedlots, the term "feeding area" is used to describe where the feeder cattle were concentrated following shipment after sale. Major feeding areas are identified by mapping the destinations to which feeder cattle were shipped after they were sold at the video auction. The geographic boundaries of the market areas associated with these major feeding areas are determined by mapping shipment data and by calculating spatial statistics. Maps can identify where feeder cattle that were eventually shipped to a feeding area after sale were located at the time they were sold at the auction. Thus, mapping assumes that shipments define the market area. However, shipment data may not provide a clear picture of the market area boundaries since the mappings of different market areas may have substantial overlaps.

Spatial statistics have been used to identify geographical groupings for different types of variables, including economic characteristics, and may help provide information about the location of market area boundaries. This study examines the ability of traditional spatial statistics to adequately identify empirical market areas for feeder cattle and also proposes an alternative statistic for identifying empirical market areas.

Finally, this study determines the impact on feeder cattle prices of buyer concentration where concentration is defined as the dominance of purchases in a county by buyers from one feeding area. This is accomplished by regressing feeder cattle prices on a spatial statistic developed in this study which measures the proportion of cattle purchased in each county by buyers from the feeding area.

Spatial Market Theory

The sizes and shapes of market areas have been addressed frequently in the literature during the last several decades. Classical spatial theory suggests that spatial markets tend to be monopolistically competitive[3] and that market areas tend to be shaped as hexagons with processing plants near the center of the market area (Chamberlin; Bressler and King; Greenhut).

However, the monopolistically competitive model assumes that the distribution of resources and population of buyers and sellers are evenly distributed across space (Greenhut). Both of these assumptions are violated in feeder cattle markets since feeder cattle are distributed unevenly because of an uneven distribution of feed resources. Also, feeder cattle buyers tend to be located near beef processing plants (see endnote 1).

Greenhut (p. 54) argues that when buyers and sellers are unevenly distributed over space, oligopoly, or in this case oligopsony theory, provides a more descriptive model of feeder cattle buyer behavior than monopolistic competition. That is, buyer market areas likely overlap[4] and buyers are aware of and react to each other. Being able to identify and separate market areas empirically is the first step in identifying market power (Greenhut and Benson; Stigler and Sherwin).

Efforts to identify spatial pricing relationships and/or empirical market areas have used Granger causality (e.g., Howell; Bailey and Brorsen). However, Granger causality occasionally yields spurious results (Bessler and Kling). Stigler and Sherwin suggest that a simple test for correlation between two parallel price series is sufficient to determine if one market or two exists.

More recently researchers have investigated if agricultural commodity markets are integrated (e.g., Goodwin and Schroeder). Goodwin and Schroeder argue that if price series for two separate locations are cointegrated then only one market exists. These tests are not applicable here since they are based on aggregated prices at central locations while the data in this study are transaction data for dispersed locations. Integration tests using prices measured at central locations are also unable to describe where overlaps and single market areas exist.

In this study, shipment data are used to map empirical market areas for feeder cattle. Shipment data may not always be appropriate to identify relevant market areas since one region can be an effective competitor even if no commodity is actually shipped to another region (Greenhut and Benson, p. 8). Thus, the relevant market area for feeder cattle might be larger than that identified with shipment data. However, the results presented here will show that market areas for buyers from the major feeding areas are large and overlap substantially. Also, almost 24,000 observations are used to complete the market area maps presented in this paper suggesting that any underestimation of the size of market areas is likely small.

Test for Spatial Price Discrimination

Spatial pricing models must incorporate transportation costs as a means of comparing prices across space. Greenhut and Benson suggest that three principal spatial pricing methods exist, (1) base-point pricing, (2) free-on-board (FOB) pricing, and (3) spatial price discrimination (p. 13). Base-point pricing implies price leadership in a large geographic market with prices at all points corresponding to price at a base point minus transportation costs (assuming oligopsony). Base-point pricing requires a high degree of cooperation among buyers and is unlikely to exist in feeder cattle markets since buyers from several regional centers are competing for cattle. FOB pricing sets prices at any location equal to the mill price less transportation costs to the mill. Spatial price discrimination implies that firms pay different prices in different locations based on the level of competition at each point in space. Spatial price discrimination can be one of two forms, (1) freight absorption in which a firm discriminates against nearby sellers by paying higher prices net of transportation costs in more distant markets, and (2) phantom freight where distant sellers are paid lower prices in favor of higher prices paid to nearby sellers (Greenhut and Benson, p. 16).

Cattle at the video auction are sold FOB at their current location or at a scale near their current location. Since buyers pay all transportation costs from that point, it is anticipated that the price buyers are willing to pay for cattle is a decreasing function of distance the cattle are shipped after sale. The relationship between the successful bid price and the number of miles shipped is estimated by including a variable in the price model measuring the distance in miles each lot of cattle was shipped after sale (MILES). A squared term for MILES (MILESQ) is also included in the regression to capture the nonlinear relationship that exists between transportation costs and miles shipped (Heath and Turpin Trucking Company).[5]

The test of spatial price discrimination is conducted by determining whether buyers can successfully reduce their bids to effectively charge sellers the full cost of transportation from the seller's location. If so, then buyers are able to price cattle using the FOB pricing method. But, as a result of competition, buyers are unable to charge sellers in distant locations the full costs of transporting their cattle, then buyers are forced to absorb a portion of the freight costs (freight absorption). Conversely, buyers are said to be charging phantom freight to distant sellers if they effectively charge these sellers more than the costs of transportation. Discounts for transportation costs predicted by the price model in this study are compared to estimates of actual transportation costs paid by buyers to determine if buyers practice FOB pricing in feeder cattle markets, are forced to absorb freight on distant purchases, or charge phantom freight on cattle purchased from distant locations.

Predicted discounts for transportation costs are obtained by multiplying the regression coefficients for MILES and MILESQ by the number of miles the cattle were shipped after sale and by the number of miles squared, respectively, then summing the results. When estimating this discount, some assumption about the intercept term relating prices to distance shipped was necessary. This is done by assuming that the predicted discount was equal to actual transportation costs at 100 miles and solving for the intercept ($0.357/cwt.).[6]

Actual transportation costs incurred by buyers for each lot of cattle are estimated using trucking rates provided by livestock trucking firms.

Spatial Statistics

The geographical distribution of feeder cattle suggests that some type of spatial autocorrelation or grouping of purchases by feeder cattle buyers exists since feeder cattle supplies are not evenly distributed across space. These types of spatial data can be described by spatial statistics, or statistics based on data measured at specified locations (Haining 1990). Spatial statistics are commonly used in the geography and economic geography literature to determine if various phenomena occur in spatial clusters. For example, two general spatial autocorrelation indices, the Moran and Geary statistics, have been used to identify whether cancer mortality rates are more likely to occur in adjoining counties or are randomly spread across spatially dispersed counties (Haining 1984). The Moran statistic (I) takes the following form:

(1) $$I = \left(\frac{n}{L}\right) \frac{\sum_{i=1}^{n}\sum_{j=1}^{n}\left(x_i - \bar{x}\right)\left(x_j - \bar{x}\right)\delta_{ij}}{\sum_{i=1}^{n}\left(x_i - \bar{x}\right)^2},$$

where n is the number of areas being considered (in this study counties); L is the number of links or common borders in the system; x_i and x_j are the i^{th} and j^{th} counties, respectively; $\bar{x}$ is the mean value for all areas; and δ_{ij} is 1 if x_i and x_j are contiguous and 0 otherwise. The Geary statistic (C) is calculated as follows:

(2) $$C = \left(\frac{n-1}{4L}\right)\frac{\sum_{i=1}^{n}\sum_{j=1}^{n}\left(x_i - x_j\right)^2 \delta_{ij}}{\sum_{i=1}^{n}\left(x_i - \bar{x}\right)^2},$$

The Moran and Geary statistics are similar in that they measure the relative covariance among groups of contiguous areas relative to the variance for all areas. Also, both the Moran and Geary statistics are distributed as standard normal variates (Haining 1990, p. 233; Taylor p. 121-22).

While the Moran and Geary statistics can be used to determine if areas like counties are grouped by economic characteristics, they fail to identify where within a group of counties clustering is occurring. This suggests the Moran and Geary statistics are of limited value in identifying empirical market areas. In fact, past economic studies using the Moran and Geary statistics have been required to use theoretical boundaries to delineate market areas (e.g., Fik 1988; Fik 1991; and Haining 1984).

Since distance and its associated costs are expected to be the principal economic factors determining market areas, a measure of grouping based on distance is expected to be more helpful in identifying empirical market areas than measures based on physical contiguity. Getis and Ord suggest a distance statistic of the following form to identify spatial groupings:

(3) $$G_i(d) = \frac{\sum_{j=1}^{n} w_{ij}(d)\, x_j}{\sum_{j=1}^{n} x_j}, \quad j \neq i,$$

where w_{ij} is a symmetric one/zero matrix with ones for counties within distance d from i and zeros for all other points including i itself. The numerator is the sum of all x_j (cattle sold at the video auction) within distance d of county i but not including x_i. The denominator sums all x_j not including x_i (Getis and Ord, p. 190). It is possible that the G_i statistic could be used to identify market area since it examines groupings for particular characteristics within a set distance rather than requiring areas to be physically linked. In this study, cattle sales within a set distance of a particular feeding area are examined using G_i to determine if the proportion of sales within, say 100 miles of the feeding area, is statistically larger than if sales were evenly distributed across space (Getis and Ord, pp. 191-92).

However, the G_i statistic may also be problematic when measured using cattle sales since supply is not evenly distributed and G_i will fluctuate with available supply. This suggests that a different measure based on relative demand rather than relative supply should be developed if buyer market areas are to be described adequately. The following statistic is based on relative demand and is used in this study to determine those geographic areas where the purchases of cattle from each of the major feeding areas is statistically larger than expected, and , hence, where the boundaries of the primary market areas exist.

(4) $$BT_{ik} = \frac{x_{ik}}{\sum_{k=1}^{K} x_{ik}},$$

where x_{ik} are purchases in county i by buyers from major feeding area k, and K is the total number of feeding areas. The numerator represents purchases by buyers from one feeding area while the denominator represents all purchases in a particular location. The expected value of BT_{ik} is the proportion of all cattle offered for sale that were purchased by buyers from a particular feeding area.

BT_{ik} is used to identify those states where the proportion of sales are statistically larger than expected and thus indicates if a given state is in the primary market area for a particular feeding area. Since the distribution of BT_{ik} is unknown, the hypothesis $BT_{ik} - (\sum_{k-1}^{K} x_{ik})/K$ for each market area is tested with bootstrapping (Noreen). The bootstrap is a nonparametric Monte Carlo procedure which requires no distributional assumption. BT_{ik} is also calculated for each county and included in the price model to ascertain if concentration of purchases in a county by buyers from one feeding area tends to reduce feeder cattle prices.

Regression Model

A competitive input market specifies that the price of an input (i.e., feeder cattle) equals the value of its marginal product (VMP) to the buyer while monopsonists or oligopsonists are able to purchase a factor(s) at a price below its VMP (McAfee and McMillan; Greenhut, p. 195). Consequently, a test for oligopsonistic behavior in feeder cattle markets should include a test for differences between feeder cattle prices and buyers' VMPs.

In an auction, especially a video auction as used here, the number of buyers bidding for a particular lot of cattle may be limited by the location of the cattle and their quality characteristics. Counties that are dominated by a few buyers are expected to have prices below the buyer's VMP as a result of lessened competition. Conversely, counties where buyers from a number of feeding areas buy cattle, or where primary market areas overlap, would expect relatively high buyer competition resulting in prices closer to the highest bidder's VMP.

Successful bids at cattle auctions are also a function of cattle quality, market conditions, merchandising strategies, and market structure (Schroeder et al.; Buccola; Bailey, Brorsen, and Fawson; Faminow and Gum). A hedonic model for successful feeder cattle bids is the following:

$$b_m = a_0 + \sum_{p=1}^{P} c_p LC_{mp} + \sum_{q=1}^{Q} d_q MC_{mq} + \sum_{s=1}^{S} f_s MS_{ms} + e_m \, , \tag{5}$$

where m = 1, 2, 3, . . . , M, and M is the number of lots sold during a particular auction; b_m is the highest bid on the m^{th} lot measured in $/cwt. and is the FOB ranch price; LC_{mp} is the p^{th} lot characteristic for the m^{th} lot of cattle (including merchandising strategies); MC_{mq} is the q^{th} market condition; MS_{ms} is the s^{th} market structure measure; e is the error term; a_0 is the intercept; and the c's, d's, and f's are parameter estimates.

The video auction data are cross-section time-series but with unequal numbers of cross-section observations. Contemporaneous correlation can be expected among the cross-section observations. The parameters of equation (5) were estimated with a one-way random effects model with the random effects being associated with time (Judge et al.). LIMDEP's feasible generalized least-squares algorithm for panel data is used to estimate the parameters.

Data

Superior Livestock Auction (SLA) of Brush, Colorado, provided price and buyer information for cattle sold and buyers' names and locations between January 1987 and

December 1992. During the data period, SLA held 103 video sales and sold almost 3 million feeder cattle.[7] Mileage between cattle location at the time of SLA's sale and the destination specified on SLA's shipment records[8] was used to measure price differentials due to buyer transportation costs. Approximately 20% of the lots had no destination specified. In this case, the average distance for the other lots sold from that state was used. The location of each lot of cattle was established from information included in SLA's sales catalogues. Lot characteristics, such as number in the lot, estimated delivered weight, and breed, were also obtained from SLA's sales catalogues.

Table 1 specifies the explanatory variables used in estimating equation (5). Table 2 presents summary statistics for the video auction data. Lot characteristics included a binary variable for sex equaling 1 for steers and 0 for heifers (STEERS). The number of cattle in the lot (NUMBER) and NUMBER squared (HDSQ) are included to capture any price differentials resulting from economies of size resulting from handling large lots. TRUCK is 1 if the total weight of the lot was at least 40,000 (about one truckload) and 0 otherwise.

Since cattle were sold FOB the seller's location and for future delivery, WRISK is included in the equation as the ratio of an acceptable deviation in weight above the estimated delivered weight specified in the sales catalogue description and the price slide in cents/lb. offered by the seller (see Bailey and Peterson, p. 395). The breed designations are a set of binary variables that best describes the breed(s) in each lot.[9]

Flesh and frame[10] characteristics basically conform to the descriptions provided in the sales catalogs.[11] The uniformity of the lot (UNIFORM) is a binary variable indicating price differentials for lots that were uniform in size and weight, as indicated in the sales catalogue, relative to non-uniform lots.

The origin, or place the cattle were born, is assumed to influence prices because of the reputation cattle from different parts of the country have for feeding efficiency (Bailey, Brorsen, and Fawson). A set of binary variable for origin are included for different regions with the MIDWEST acting as the base (see footnotes to Table 1). The origin regions designated basically group states by types of cow/calf operations and weather conditions.

The market characteristics in equation (5) include the closing quote for the feeder cattle futures on the day of the video auction sale for the futures contract with a maturity closest to but not preceding the delivery date specified by the seller (FUTURES). The Friday quote for the appropriate futures contract was used if sales were on Saturday. The number of days between the date of the video auction sale and the delivery date specified by the seller (DATE) is also included in equation (5). Together FUTURES and DATE correct for different price expectations across time.

Market structure variables include a test for market power, ($b_m = VMP_{m1}$), which is conducted as a one-tailed t-test of the parameter estimate for BT_{ik} in equation (5). In addition, a test for price differentials between locations located within more than one market area and location within just one market area is conducted as one-tailed t-test of the parameter estimate for variable called OVERLAP in equation (5) where OVERLAP equals 1 if a lot was in a state located in more than one market area and 0 otherwise.

The expected signs of the coefficients of the lot characteristics and market conditions are similar to those in past research (e.g., Schroeder et al.; Bailey and Peterson; Faminow and Gum; Buccola). For example, holstein steers are expected to receive lower prices than English breeds since holsteins have lower meat yields and lower feed efficiency than English breeds.

Mapping Major Feeding Areas

Major feeder cattle feeding areas and their associated market areas can be illustrated by plotting the data. Major feeding locations are shown by mapping the density of shipments to each county on a map of the United States. Conversely, seller locations are shown by plotting the density of purchases from each county. Based on the mapping of destinations, four major feeding areas were identified--the area along the Missouri River in Nebraska and Iowa (Omaha); the Nebraska Panhandle, southeastern Wyoming, and northeastern Colorado (Greeley); western Kansas and southeastern Colorado (Dodge City); and the Texas/Oklahoma Panhandle (Amarillo). The remainder of the United States is divided into the West, Northern Plains, Southern Plains, and the East. Thus, eight feeding areas (K=8) where considered when calculating BT_{ik}.

Results

Market Area Maps

Figures 1 and 2 present the density maps of feeder cattle purchases for the Dodge City and Amarillo feeding areas.[12] These maps demonstrate that the market areas are not hexagons as assumed in the classic spatial model (Bressler and King). New theory is needed to describe the way spatial markets really work since, as demonstrated here, market areas for feeder cattle are large, irregularly shaped, and overlap substantially.

The maps suggest that transportation costs do partly determine the market area for feeder cattle since buying densities for Amarillo are large south of Amarillo, while buying densities for Dodge City are higher in Colorado and areas north of Colorado than the buying densities for Amarillo. Dodge City buyers spread their purchases more evenly across the other regions than buyers from Amarillo. However, the relative absence of purchases in the western Kansas area by buyers outside of the Dodge City feeding area is striking (figure 2) suggesting that Dodge City buyers are very aggressive about buying cattle close to their location.

Identifying Market Areas Using Spatial Statistics

While mapping does illustrate that feeder cattle market areas do not conform to traditional spatial theory, they are unable to clearly delineate market area boundaries since so much overlap in the procurement areas exists. Table 3 lists the Geary and Moran statistics for the four major feeding areas and indicates that negative spatial autocorrelation exists for the Omaha, Greeley, and Dodge City markets. This suggests that dislike numbers of cattle were purchased in adjoining counties by buyers in these three feeding areas. This implies that size of purchases are not even across adjoining counties and are heavy in one location and light in others. Conversely, the Moran statistic for the Amarillo feeding area indicates that positive spatial autocorrelation existed for purchases by buyers from that region. In other words, if purchases by buyers from Amarillo were large in a given county, they tended to be large in adjoining counties. These statistics provide little relevant information about where market areas for feeder cattle exist, but they do show that purchases are not evenly distributed.

The G_i statistic is calculated for distances from a specific point. The four counties with the largest numbers of cattle shipped into them in each of the four major feeding areas were identified and the G_i calculated for those counties. Table 4 presents the G_i for Grant County, Kansas, and similar results are found for the other counties for which the G_i was calculated. The G_i tests show that the distribution of shipments across space is uneven. But, the sign of the G_i's follow no obvious pattern. The problem is that the G_i statistic is simply reflecting the irregular distribution of feeder cattle supply. Consequently, the G_i has limited use is defining market areas for feeder cattle since it identifies supply rather than demand.

Table 5 lists those states identified using the BT_{ik} statistic to be part of the primary market area associated with each major feeding area. The information in Table 5 illustrates clearly that transportation costs determine market areas since buyers at the feeding areas buy larger than expected numbers of cattle in the areas where they have a transportation cost advantage over the other market areas.

Buyers from Omaha and Amarillo are located near the edges of the buying activity in their primary market areas with the market areas for both extending away from the other major feeding areas. Buyers in the Amarillo feeding area buy a relatively large proportion of the cattle located to the south of Amarillo compared to areas north of Amarillo, while buyers in the Omaha feeding area tend to buy a relatively large proportion of cattle located to the north of Omaha. The Dodge City and Greeley feeding areas lie between Omaha and Amarillo, but their primary market areas also extend away from Omaha and Greeley to the east and south. Greeley and Dodge City basically share the market in Colorado while Dodge City shares Oklahoma with Amarillo and Missouri with Omaha (Table 5).

Greeley's primary market area includes the states of Pennsylvania, Mississippi, and West Virginia. Obviously, transportation costs do not explain why these states would be in the Greeley market area. However, cattle from these states tended to have characteristics somewhat different than average (e.g. were light steers) suggesting cattle from these states served specific needs of a particular group of buyers. Also, relatively small numbers of cattle were sold from these states.

Tests for Spatial Price Discrimination and Price Differences in the Market Areas Resulting from Buyer Concentration

Table 6 presents paired t-tests, based on distance, between the predicted reduction in the successful bid for transportation costs and estimated actual transportation costs paid by buyers. These results confirm that buyers practice spatial price discrimination by absorbing freight costs on cattle they purchase in distant locations. On the average, buyers begin to absorb freight if the cattle they are buying are more than 400 miles from their final destination. This provides a disincentive to purchase distant lots and less than 35% of the lots are shipped fewer than 400 miles and over 70% fewer than 600 miles.

Table 7 presents the feasible generalized least-squares parameter estimates of the hedonic price model (equation (5)). Parameter estimates and signs of the parameter of lot and market characteristics are similar to the results of past studies using hedonic price models of feeder cattle prices (e.g., Buccola; Faminow and Gum; Schroeder et al.; Schultz and Marsh).

The parameter estimate for BT_{ik} (-1.136) indicates counties dominated by buyers from one feeding area receive lower prices than counties where buyers from several feeding areas are buying cattle, suggesting feeder cattle buyers are able to discriminate between the prices they pay for feeder cattle based on location. In the case of monopsony (BT_{ik} = 1), county price levels for 700-800 lb. steers would be depressed by about $8-$10/head. These results show that the impact of regionalized concentration is larger than overall concentration in a market when compared to previous studies (e.g., Bailey, Brorsen, and Fawson).

The results also show that feeder cattle producers located where two or more market areas overlap (OVERLAP), receive substantial premiums compared to those located in only one market area (about $1.26/cwt.). A Wald test (Judge et al., p. 757) testing the restriction that the parameter estimates for BT_{ik} and OVERLAP summed to zero could not be rejected, suggesting the video auction is a competitive market for cattle lots offered for sale from counties located in more than one of the primary market areas.

Feeder cattle producers in areas with few local buyers can take some comfort in knowing that market areas for feeder cattle are large. Also, buyers are willing to absorb part of the transportation costs for cattle they purchase in distant locations. But, domination by buyers from only one market area does provide these buyers with market power.

Conclusions

Little information has been available about the size and shape of feeder cattle market areas. Maps of the buying densities at a large video auction during 1987 through 1992 presented in this study for buyers from major feeding areas suggest that feeder cattle market areas are not hexagonal. They are irregularly shaped and overlap extensively. Thus, new theories are needed to describe the size and shape of spatial markets.

An examination of primary market areas for feeder cattle using spatial statistics revealed that market areas are determined by relative transportation costs, and that the feeding areas may actually lie on the edge of a market area and extend in a direction away from competing feeding areas. While this behavior is consistent with some of the traditional theory of market areas for agricultural products (e.g., Bressler and King p. 145) traditional theory fails to explain why overlaps in market areas for feeder cattle exist.

Feeder cattle buyers act as oligopsonists or monopsonists in counties where most cattle are purchased by buyers from one feeding area (i.e., they pay a price less than the VMP of the input). Conversely, sellers of cattle located where two or more market areas overlap receive premiums since competition is greater than in counties with high buyer concentration.

Feeder cattle buyers practice spatial price discrimination by absorbing freight costs for cattle purchased in distant locations and discounting nearby cattle by amounts larger than estimated transportation costs. Sellers located distant from the major feeding areas should be encouraged that feeder cattle market areas are large and that some freight absorption is occurring.

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Endnotes

1. The methodology used in this study could also be applicable to fed cattle markets.

2. The number of feedlots with under 4,000-head capacity declined by almost 42% in the 13 major feeding states between 1980 and 1992, while the number of feedlots with over 4,000-head capacities increased by over 6% during the same period. Marketings by feedlots with under 4,000-head capacity declined from 39% of total marketings in the 13 states in 1978 to just over 23% of total marketings in 1992. During the same period, areas with large and/or modernized packing facilities such as Colorado, Kansas, Texas, Nebraska, and Oklahoma increased the number of fed cattle marketed by 25%, while marketings in the rest of the 13 major feeding states declined 34% (Western Livestock Marketing Information Project).

3. That is, plants tend to act as monopolists within an area determined by transportation costs and location of other plants.

4. Greenhut points out that these overlaps occur only if buyers practice spatial price discrimination in the form of freight absorption.

5. Although one livestock trucking firm is cited here, a number of trucking companies from several regions were contacted about the cost of trucking livestock. All indicated that a nonlinear relationship between costs and miles shipped exists.

6. Actual transportation costs/cwt. were estimated to be $0.56/cwt. for shipments of 100 miles (($2.50/cwt.*100)/450 cwts.)), and the intercept was calculated by solving the following equation: .002(MILES) + .000000326(MILESQ) + a = $0.56.

7. Feeder cattle are defined for this study as steers and heifers not sold as breeding stock. That is, all steers and heifers weighing less than 1000 lbs. each and not listed as breeding stock.

8. This was the destination specified on the trucking record to which the cattle were shipped and not the buyer's home location.

9. Some subjectivity and grouping was required to separate lots into these broad categories. Greater detail about particular breeds is included in the sales catalogues, but little detail is given there about the number within each lot fitting each breed type. Consequently, the broader breed categories specified here are used.

10. One should expect that correlations between breed, weight, frame, and flesh characteristics should exist. The collinearity diagnostics in PROC REG in SAS (Condition

Index) were used to determine if any multicollinearity existed in the variables. This resulted in several variables not being considered for estimation in equation (5).

11. Standard frame and flesh scores are not provided in the sales catalogues and subjective appraisal of the video auction representative who composed the description of a particular lot in the sales catalogue is used here. Some additional grouping to fit the relatively broad categories presented here was also done by the researchers.

12. All market areas exhibited substantial overlaps. The Amarillo and Dodge City maps are show here for illustrative purposes. Maps for the other market areas, and also for destinations to which cattle were shipped, are available from the authors.

Table 1. Independent Variables Used in the Feeder Cattle Price Model[a]

Independent Variables

Lot Characteristics

Sex: STEERS
HEIFERS*
Number in lot (NUMBER)
Average estimated weight in lbs. (WEIGHT)
Number-squared (HDSQ)

Truckloads: At least 40,000 lbs. (TRUCK)
Fewer than 40,000 lbs.*
Weight Risk (WRISK)[b]
Miles from location to delivered point (MILES)
MILES squared (MILESQ)
Breed: HEREFORD*, ENGLISH-CROSS, ENGLISH-EXOTIC-CROSS, EXOTIC-CROSS, ANGUS, DAIRY

Flesh: Medium-Heavy (MH),
Medium (MF),
Light*
Frame: Large, Medium (MED), Small*

Horns: NO HORNS, SOME HORNS, HORNED*

Uniformity: Uniform lot (UNIFORM)
Nonuniform lot*

Origin of the Cattle:
Western States (WEST)[c]
SOUTH[d]
MIDWEST*[e]
Upper Midwest (UPPER)[f]
West Coast (WCOAST)[g]
Lower Southwest (LSW)[h]
EAST[i]

Market Characteristics

Feeder Cattle Futures price (Futures)
Seasonality: 1st QUARTER
2nd QUARTER
3rd QUARTER
4th QUARTER*
Days to delivery (DATE)

Market Structure

BT_{ik}[j]
OVERLAP[k]
PLACE[l]
YEAR Dummies (YEARS): 1987-89*
1990-92

*Base for a set of binary variables such as sex, breed, etc.
[a]See equation (5).
[b]The ratio of an acceptable variance in weight above the estimated delivery weight and the price slide in cents/lb. specified by the seller.
[c]Montana, Wyoming, Idaho, Utah, and Nevada.
[d]Mississippi, Florida, Louisiana, Alabama, Arkansas, North Carolina, Georgia, Tennessee, and Kentucky.
[e]Nebraska, Kansas, Colorado, Missouri, Illinois, and Iowa.
[f]South Dakota, North Dakota, Minnesota, and Wisconsin.
[g]California, Arizona, Oregon, and Washington.
[h]Texas, Oklahoma, and New Mexico.
[i]States east of Illinois and north of Kentucky.
[j]The *t*-statistic for BT_{ik} tests the hypothesis that $b_m = VMP_{m1}$, where 1 indicates the buyer with the largest VMP for lot m.
[k]Binary variable equalling 1 if the lot is in a location located in more than one market area and zero otherwise.
[l] Trend variable indicating the order in which the lot was sold within a sale.

Table 2. Descriptive Statistics for the Video Auction, 1987-92.

Item	Value During 1987-92
General Characteristics:	
Number of Cattle Offered for Sale	3,705,663
Number of Cattle Sold[a]	2,846,351
Average Number of Head in Each Lot	122
Average Estimated Delivered Weight (lbs./head)	582
Average Miles Shipped After Sale	544
Uniform Lots (%)	16
Breed:	
Hereford (%)	2
English Cross (%)	17
English-Exotic Cross (%)	66
Exotic Cross (%)	8
Angus (%)	2
Dairy (%)	5
Frame:	
Large (%)	39
Medium (%)	59
Small (%)	2
Flesh:	
Heavy to Medium Heavy (%)	5
Medium	89
Light	6
Origin of the Cattle:[b]	
West (%)	27
South (%)	13
Midwest (%)	15
Upper (%)	3
WCoast (%)	9
LSW (%)	22
East (%)	0.3
Unknown (%)	11

[a] If bids were deemed by the seller to be unacceptable, the seller could reject the bid within a short time after the final bid was placed.
[b] See footnotes to Table 1.

Table 3. Moran and Geary Statistics for the Four Major Market Areas

Market Area	Geary Statistic	z	Moran Statistic	z
Omaha	1.422	-8.436**	-0.100	-0.937
Greeley	1.286	-6.089**	-0.094	-0.845
Dodge City	1.126	-2.933**	0.139	1.398
Amarillo	1.022	-0.474	0.271	2.476**

**Statistically different than the expected value at the 1% level.

Table 4. G_i Statistic for Grant County, Kansas

Distance (miles)	G_i	Z
0 - 100	0.044	9.471**
100 - 200	0.055	- 8.941**
200 - 300	0.124	8.858**
300 - 400	0.106	-13.420**
400 - 500	0.155	36.533**
500 - 600	0.119	-19.265**
600 - 700	0.130	24.517**
700 - 800	0.055	-20.170**
800 - 900	0.047	-29.631**
900 - 1000	0.011	-7.426**
1000 - 1100	0.032	0.903
1100 - 1200	0.012	-3.813**
1200 - 1300	0.021	-13.056**
1300 - 1400	0.029	27.241**
1400 - 1500	0.006	-14.774**
1500 - 1600	0.001	-10.938**
1600 - 1700	0.005	10.737**

** Statistically different that the expected value at the 1% level.

Table 5. Market Areas Identified by the BT_{ik} Statistic.

Major Feeding Area	States in the Market Area
Omaha	Idaho, Illinois, Iowa, Minnesota, Missouri, Montana, Nebraska, North Dakota, South Dakota
Greeley	Colorado, Mississippi, Pennsylvania, West Virginia
Dodge City	Arkansas, Colorado, Kansas, Missouri, Oklahoma
Amarillo	Florida, Louisiana, New Mexico, Oklahoma, Texas

Table 6. Test for Spatial Price Discrimination Using Difference Between Actual and Predicted Transportation Costs.[a]

Distance (Miles)	Actual Costs ($/cwt.)	Predicted Costs ($/cwt.)	Difference ($/cwt.)[b]	Paired T-Test
100-200	0.601	0.875	-0.274	-628.888**
200-300	1.003	1.200	-0.197	-374.853**
300-400	1.410	1.510	-0.100	-158.885**
400-500	1.807	1.799	0.012	22.383**
500-600	2.221	2.302	0.148	260.866**
600-700	2.586	2.302	0.284	258.421**
700-800	2.990	2.538	0.452	309.642**
800-900	3.399	2.759	0.640	392.909**
900-1000	3.793	2.953	0.839	434.239**
1000-1100	4.188	3.131	1.057	409.898**
1100-1200	4.600	3.298	1.302	408.652**
1200-1300	4.982	3.436	1.546	448.071**
1300-1400	5.381	3.562	1.818	411.707**
1400-1500	5.783	3.672	2.111	436.970**

[a] Estimated actual costs were calculated using quotes for major trucking companies during May, 1994 and deflating these prices to November 1990, the midpoint of the data (Heath and Turpin Trucking Company; American Trucking Association Information Center).
[b] The mean difference between actual and predicted transportation costs.

Table 7. Feasible Generalized Least Squares Parameter Estimates for Feeder Cattle Price Model Measuring the Impact of Market Concentration (Equation (1))[a]

Independent Variable	Parameter Estimate	Independent Variable	Parameter Estimate
INTERCEPT	112.620 (142.863)**	FLESH:	
FUTURES	0.823 (33.309)**	MH	-0.986 (-5.003)**
STEERS	5.362 (75.532)**	MF	-0.959 (-8.018)**
NUMBER	0.003 (11.329)**	FRAME:	
WEIGHT	-0.055 (-153.165)**	LARGE	0.749 (6.979)**
HDSQ	-0.685E-08 (-0.146)	MED	0.0198 (0.221)**
BREED:		HORNS:	
ENGLISH-CROSS	-0.039 (-0.157)	NO HORNS	0.576 (4.536)**
ENGLISH-EXOTIC CROSS	-0.241 (-1.001)	SOME HORNS	0.342 (3.032)**
EXOTIC-CROSS	-0.694 (-2.579)**	SEASONALITY:	
ANGUS	0.014 (0.037)	1st quarter	3.041 (5.404)**
DAIRY	-5.951 (-19.580)**	2nd quarter	1.687 (1.999)*
		3rd quarter	3.875 (4.647)**

Table 2. (Continued)

Independent Variable	Parameter Estimate	Independent Variable	Parameter Estimate
LOCATION:		WRISK	-0.299 (-8.331)**
WEST	1.115 (11.555)**	MILES	-0.002 (-7.254)**
SOUTH	-1.986 (-17.290)**	MILESQ	0.326E-06 $(1.631)^{b}$
UPPER	2.342 (11.472)**	UNIFORM	1.302 (12.346)**
WCOAST	0.811 (2.329)**	MARKET STRUCTURE:	
LSW	-0.897 (-9.398)**	BT_{ik}[c]	-1.136 (-6.158)**
EAST	-1.380 (-10.332)**	OVERLAP	1.257 (13.217)**
TRUCK	-0.308 (-1.368)	PLACE	0.001 (2.862)**
		YEARS	7.318 (10.889)**
DATE	-0.003 (-2.414)*		
		Observations	23,713
		R^2	0.642

*Denotes statistically different than zero at the 5% level.
**Denotes statistically different than zero at the 1% level.
[a] *t*-values are in parentheses.
[b] The parameter estimate for MILESQ is statistically significant different than zero at the 10% level.
[c] This is a one-tailed test to determine if prices decline as purchases in a county become dominated by buyers from one market area (i. e. H_0: b_m = VMP_{m1}).

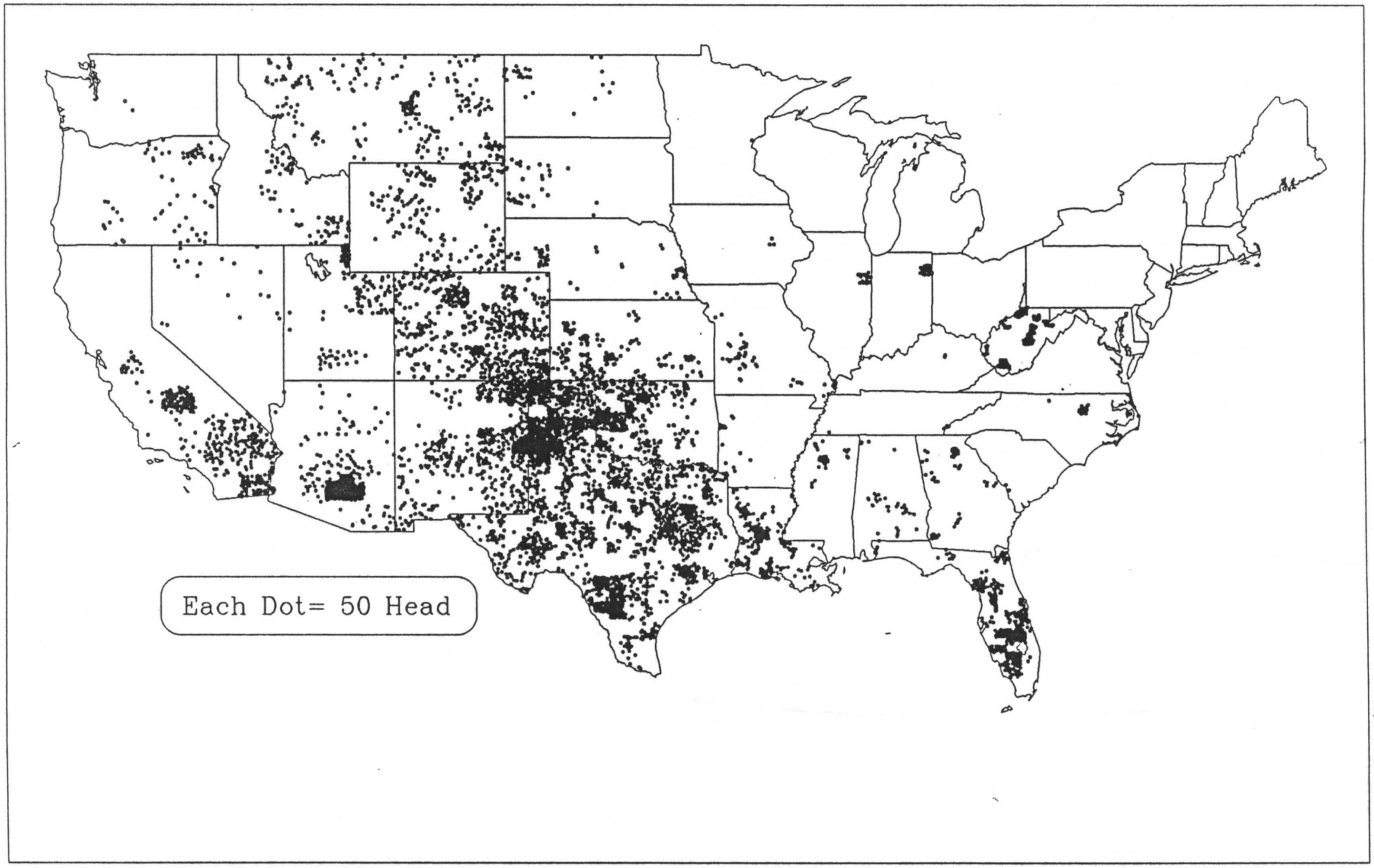

Figure 1. Location of feeder cattle purchased by buyers from the Amarillo feeding area, 1987-1992

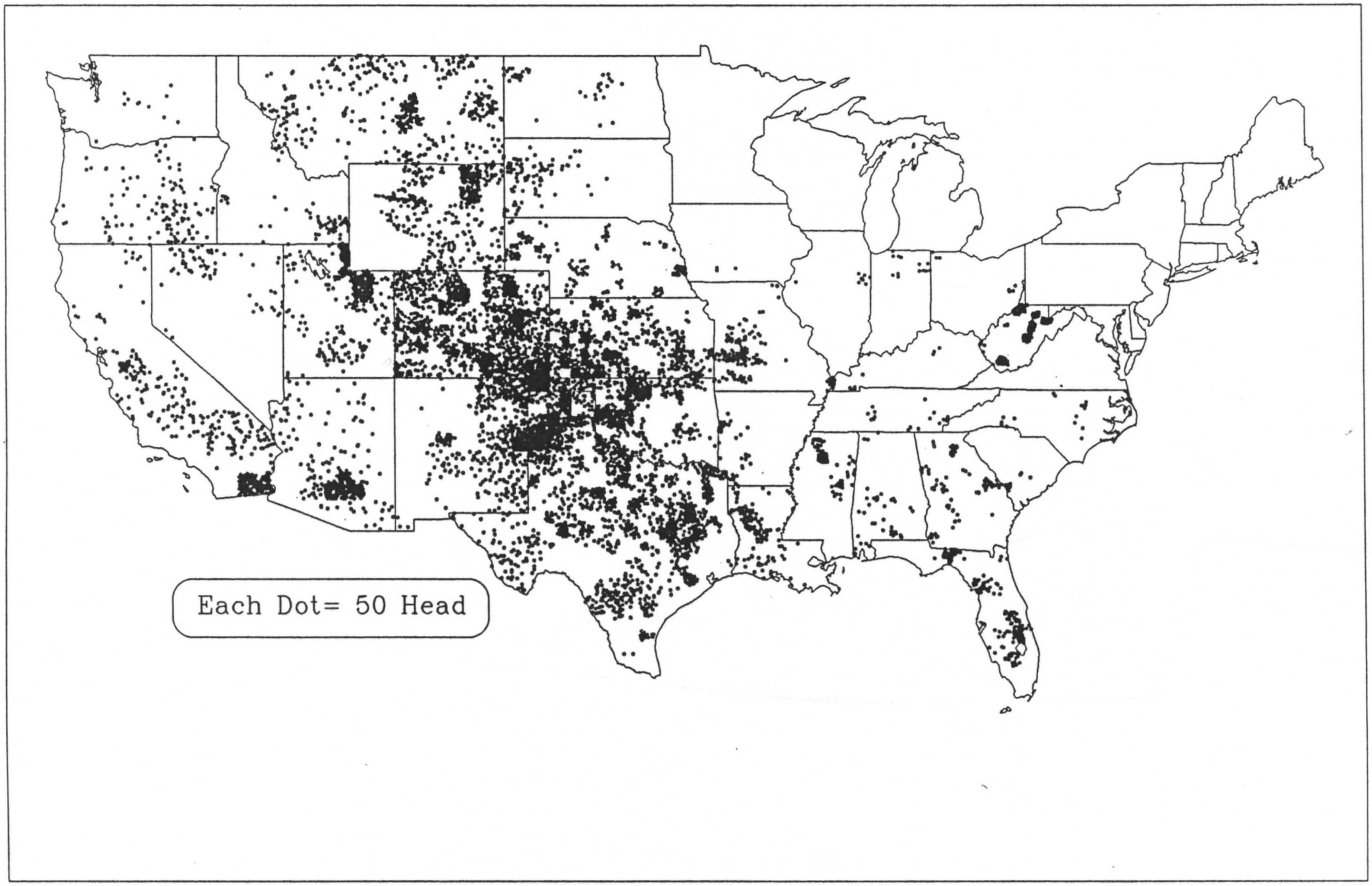

Figure 2. Location of feeder cattle purchased by buyers from the Dodge City feeding area, 1987-1992